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Experience has shown that check valves deployed in dual fuel gas turbines can be the cause of a myriad of maintenance problems. A new design promises to change all that.

Check it out

While working with power plant owners and operators over the past ten years, Parker Instrumentation has become increasingly aware of a prevalent reliability issue encountered at dual fuel gas turbine sites. It seems that regardless of a turbine's age, frame size or manufacturer, they virtually all have issues with the check valves that are commonly deployed in the fuel oil, water injection, or purge air lines close to the turbine combustor cans. Even the newer turbine models equipped with NO_x reduction technology and the 'latest and greatest' equipment can have issues associated with fuel supply and purge systems.

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Having analysed its experiences with this type of equipment, there seemed to Parker to be two possible paths of corrective action: to redesign the fuel and purge systems from scratch, or look at greatly improving the performance of the check valves in the existing systems. Since most plant owners and operators were not interested in the high cost and extended downtime of a re-engineered fuel system, Parker Instrumentation has chosen to commit its resources to engineering a new type of check valve called the CB Series for the demanding conditions that could be encountered in this application.

There is a long history of performance issues with all manufacturers' check valve products used for purge air, liquid fuel and water injection applications. It was discovered that this was primarily due to the fact that most people considered a check valve to be a check valve, and would historically use any standard instrumentation product and expect them to perform in this difficult turbine environment.

Figure 1. A core element of the CB Series check valve is a self-centering ball

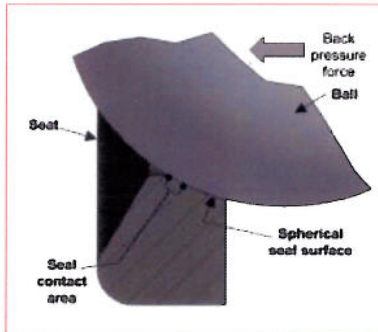

Figure 2. Large flow passages allow the internal cavities to drain easily, which further reduces coking effects

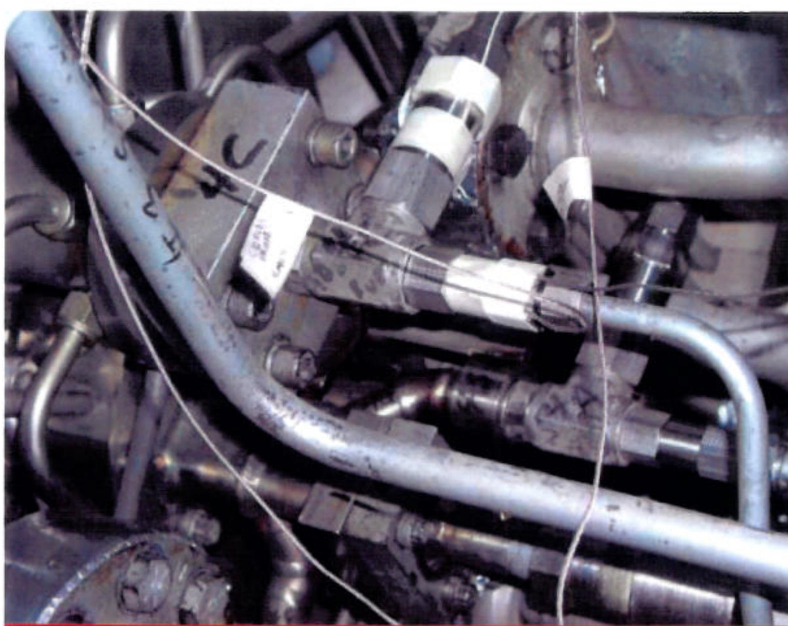

Figure 3. Parker verified operating conditions by real-world testing. Thermocouples mounted on check valves were used to profile actual temperature conditions during start up, baseload running and shutdown

Numerous failure types

A myriad of failures have been encountered on many turbine styles due to this philosophy, including seat leaks, short life, and coking problems – which lead to bigger issues of turbine trip, unplanned outages, and costly repair. Dual fuel turbine operators had learned to live with this and accept that they would have to change-out valves regularly. While individual plants operate under different conditions (for example, peaker vs baseload, fuel oil vs gas hours) the problems encountered are consistent and persistent when it comes to check valves. Most difficulties though, seem to arise from switching fuels after prolonged run hours; peaker units also tend to have more issues than baseload units due to heat-up and cool-down thermal effects.

Based on input from users at power plants in both US and international locations, Parker established what the main design criteria and performance goals should be. Some of the key items were:

- Reliable bubble tight shut-off
- Resistance to failure from coking (coking is caused when fuel oil mixes with air at elevated temperatures over time)

- Ease of repair.

Other considerations included temperature and media compatibility and flow characteristics.

Initially, installation issues were overlooked, as the key focus of the programme was on design and function, but eventually it became apparent that very few operators were willing to modify their existing turbine plumbing arrangements, and having a replacement that was a dimensional 'drop-in' was an essential element of the new design.

The starting point for the new design was an internal sealing concept based on the company's existing floating ball valve – the B-series – which has been used in virtually every fluid system imaginable. This valve employs a self-centering ball that compensates for misalignments (see Figure 1); in contrast, all other poppet-style check valves the authors have seen can be adversely affected by seat leakage when in a misaligned condition. A key design feature was to separate a traditional check valve poppet into an independent ball and cage, thereby allowing use of a micro-finished ball which has optimal sealing capabilities compared to traditional machined surfaces.

Utilizing PTFE copolymer seats also proved invaluable due to the soft and forgiving nature of the material. It forms a nearly perfect fit around the ball for an excellent bubble tight seal, and improves during turbine operating conditions. PTFE coating internal parts of the check valve has proved valuable in reducing coke deposits and build up, which leads to premature failure of other designs.

Figure 4. 'Tee' configurations of the valve

Table 1. Sample data collected from some initial site installations of CB Series check valves (up to January 2006) demonstrate reliability in demanding usage situations

Location	Application	Run hours	Fuel switches	Starts
US (Florida)	Liquid fuel	1100	18	167
	Purge air	1100	18	167
US (Tennesee)	Water injection	246	12	80
	Liquid fuel	246	12	80
China	Liquid fuel	3500	6	baseload
US (Tennesee)	Liquid fuel	240	5	25
	Purge air	240	5	25
US (Florida)	Purge air	850	8	220
US (New Jersey)	Liquid fuel	340	12	26
Middle East	Purge air	760	15	120
US (Florida)	Liquid fuel	620	12	84

Large flow passages also allow the internal cavities to drain easier, which further reduces coking effects. The valves seats and seals are designed to withstand continuous operating conditions in excess of 260°C (500°F). Parker has participated in a number of temperature studies of check valves on turbines and found that most operate between 121-176°C (250-350°F) and rarely approach 204°C (400°F).

Utilizing actual turbine temperature and operating data was integral to the design process. Considering that some turbine OEM specifications apply criteria that were found to be unrealistic, Parker chose to base all the performance aspects of the valve (temperature, pressure and flow) on empirically measured field conditions (see Figure 3). Most importantly here, the seat material options of Parkerfill and Parker Carbon (carbon graphite and carbon reinforced PTFE) are designed and optimized specifically for the demands of fuel oil, purge air, and water injection applications on turbines. These two compounds are chemically inert, highly resistant to 'hot flow', resistant to coke sticking, and most importantly provide an exceptional bubble tight shutoff. Interestingly, seal performance actually improves as the turbine heats up.

Internal testing of these components involved extensive flow and oven bake time in Parker's valve test laboratory. The seats and seals were thermally cycled and thermally soaked under pressure over a long period to simulate actual turbine field conditions. Fine tuning the valves' flow characteristics for different turbine flow requirements was also essential, to effectively negate chatter across the given flow range for each check valve type.

After extensive lab testing on the individual components and full assemblies, the valves were installed on a field unit for beta testing. Slight plumbing modifications were required on the beta unit as the dimensions had yet to be fine-tuned for 'drop-in' installation. The original turbine plumbed with Parker CB Series valves used 20 water injection and 20 fuel oil check valves. Inspections of the seats, balls and cages were performed after a six-month time span involving dozens of starts, a few fuel switches and over a hundred run hours. Both Parker and the plant operators were very pleased with the results. The original valves installed on that unit three years ago are still in operation today.

"There is a long history of performance issues with check valve products used for purge air, liquid fuel and water injection applications"

Field proven

Field history over the past three years has demonstrated the reliability of the new valve design on a wide range of turbine types and frame sizes, including systems from the two largest turbine OEMs, as well as aeroderivatives (see Table 1).

These sites have accumulated thousands of turbine run hours in addition to hundreds of fuel switches and start ups. The plant operators have found that the product's true value lies in reducing the costly turbine downtime and maintenance issues, and most are looking to expand and continue usage of the valve design within their turbine and/or fleets.

The check valve design is also available with inline filter/strainers, typically for use in fuel oil and water applications with heavy particulates. These serve to protect the check valve seats and more importantly the turbine fuel nozzles. Additionally, it can be provided in a variety of tee configurations for virtually all frame sizes (see Figure 4).